CHAPTER II.2. COST OF STOMACH CANCER

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CHAPTER II.2. COST OF STOMACH CANCER

II.2.A.　　Background

This chapter contains a discussion of the methods used to estimate the direct medical costs incurred by stomach cancer patients, and the results of the analysis for these two cost elements. It does not include information on elements such as indirect medical costs, pain and suffering, lost time of patients and unpaid caregivers, etc.[1] The reader is referred to Chapter I.1 for a discussion of the general methods and cost elements that are relevant to all benefits estimates and for a discussion of the limitations of estimating medical costs. In addition, Chapter II.1 contains information regarding the special characteristics of cost estimates for cancer.

The costs presented in this chapter were current in the year the chapter was written. They can be updated using inflation factors accessible by clicking on the sidebar at left.

Link to Chapters I.1 and II.1
Link to inflation factors

II.2.A.1　　Description

Stomach cancer, also called gastric cancer, refers in most cases to adenocarcinoma, which comprises 90 to 95 percent of all gastric malignancies. Other types of stomach cancer include lymphoma, leiomyosarcoma, carcinoid, adenocanthoma, and squamous cell carcinoma. Stomach cancer can occur in various anatomical sections of the stomach and may be limited to the mucosa of the stomach or include large portions of the stomach and other organs. In addition to these distinctions, there are two common classification systems, Lauren and Borrmanns, which provide additional definition to the description of stomach cancers (Gunderson et al., 1995). This Chapter will consider stomach cancer to cover all of the above types, in keeping with the recent oncology texts and the majority of information reviewed for this analysis.

There are approximately 24,000 cases of stomach cancer diagnosed per year in the United States. Stomach cancer is fatal in over 80 percent of all cases. It occurs with declining frequency in the United States. The

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[1] Some of these cost elements, especially pain and suffering may comprise a very large portion of the cost of cancer. However, it was not feasible to estimate this cost component for this chapter.

incidence in 1994 was 7.2 cases per 100,000 total population, down from 28.8 in 1973 (incidence represents newly diagnosed cases in a year).

Stomach cancer occurs with much greater frequency among the elderly, which is typical of most cancers. The average age at diagnosis is approximately 70 years. Only one percent of stomach cancers are diagnosed before the age of 35, and the 5th percentile of age at diagnosis is approximately 45 years. The 95th percentile is over 84 years of age (NCI, 1998). The age corresponding to the 95th percentile cannot be determined precisely because the National Cancer Institute (NCI) aggregates all occurrences over the age of 85, and 12 percent of stomach cancers are diagnosed among people age 85 or greater.

The distribution of the age at diagnosis (onset) of stomach cancer is shown in Figure II.2-1. The steep incline in the probability of stomach cancer diagnosis is clear in this diagram, with a peak around 70 years of age. The data used to generate this figure, as well as the cumulative percents of stomach cancer in each five-year increment of life are shown in Table II.2-1. The age-specific incidence data were used in Section B medical cost calculations. Data on incidence and age at diagnosis were obtained from NCI's Surveillance, Epidemiology, and End Results (SEER) reports and tables. These were obtained on line through the NCI web site at: http://www-seer.ims.nci.nih.gov in January, 1998.

II.2.A.2. Concurrent Effects

As with all cancers, stomach cancer may spread to other organs. In approximately 30 percent of patients, stomach cancer has spread to the liver at the initial diagnosis (Gunderson et al., 1995). No data were located indicating that concurrent effects unrelated to stomach cancer or its treatment were likely to occur with this disease. As noted in Chapter II.1, secondary cancers and other adverse health effects may occur due to treatment and therapy. These can induce added medical costs not considered in this chapter.

Link to II.1.B

Figure II.2-1. Age-specific Incidence of Stomach Cancer
    Based on NCI, 1998
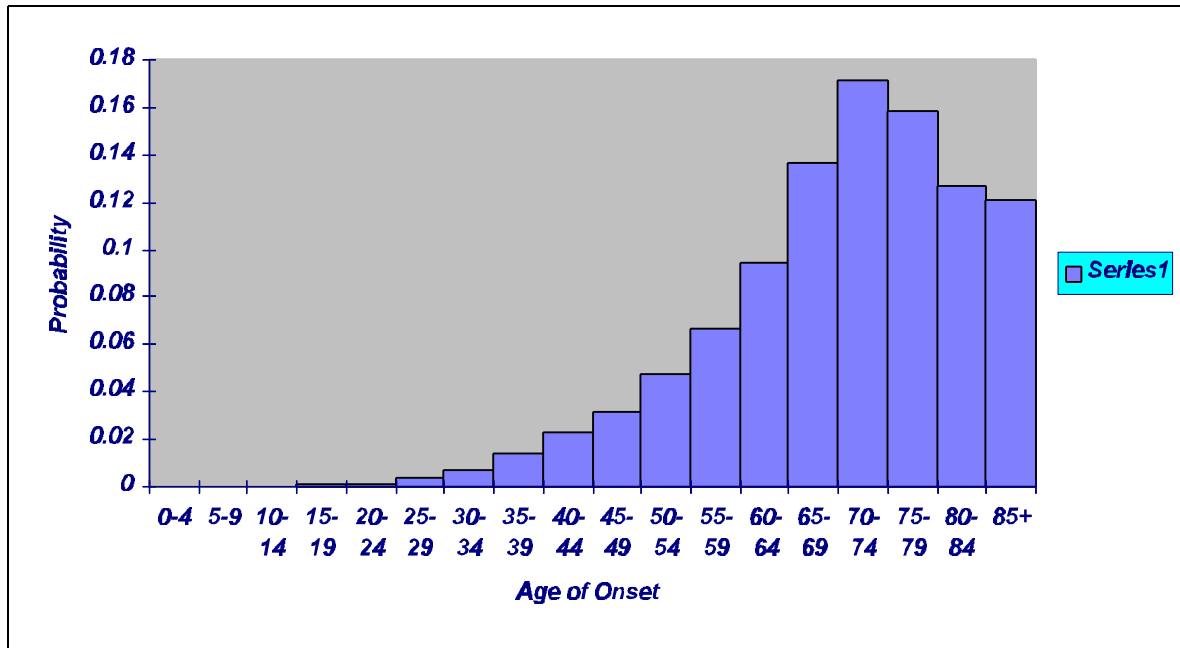
Table II.2-1. Age-specific Incidence of Stomach Cancer			
Age Group	Age-specific Rate of Diagnosis Per 100,000	Percent of All Stomach Cancer Occurring in Age Group	Cumulative Percent of Stomach Cancer
0 - 14	0	0	0
15 - 34	0.3	1	1
35 - 39	1.5	1	2
40 - 44	2.7	2	4
45 - 49	4.4	3	7
50 - 54	8.3	5	12
55 - 59	14.1	7	19
60 - 64	21.7	9	28
65 - 69	31.8	14	42
70 - 74	45.6	17	59
75 - 79	55.9	16	75
80 - 84	67.5	13	88
85+	79.4	12	100
Based on NCI, 1998			

II.2.A.3.   Causality and Special Susceptibilities

Some environmental pollutants are associated with stomach cancer. Radon is of particular concern because it has been associated with stomach cancer in numerous studies of occupationally-exposed workers (summary provided in BEIR VI, 1998). Occupational studies also indicate possible relationships between stomach cancer and coal mining and rubber and asbestos manufacturing (Gunderson, et al., 1995).

Table II.1-1 in Chapter II.1 contains a list of chemicals known or suspected of causing cancer (as reported in the EPA databases IRIS, HEAST, and HSDB). Most chemicals in the table were carcinogenic in animal studies. These studies do not provide organ-specific data because it is not generally assumed that cancer induction will always occur at the same site in humans as in animals. Consequently, the chemicals listed in Table II-1 may cause stomach cancer and/or other types of cancer. Evaluation of the likelihood of this occurrence would require additional research (risk assessment).

Link to Table II.1-1

Stomach cancer has been associated with dietary factors in some populations. It occurs at a much higher rate in Japan and some other countries than in the U.S. This difference is thought to be due to dietary differences. Studies in the U.S. have shown that people with pernicious anemia and some types of ulcers and polyps are at greater risk (Gunderson et al., 1995). Very recent reports (1998) indicate an association between the bacteria responsible for ulcers and stomach cancer, probably with ulcers as an intermediate condition. This association is plausible based on current knowledge of cellular proliferation and its role in cancer induction.

NCI provides age-, sex-, and race-specific data regarding diagnosis of stomach cancer for the diagnosis years 1990 to 1994. Some statistics from this data compilation illustrate the higher rates of stomach cancer among males and African-Americans. The rate among males has been consistently higher than in females over the years (10.8 versus 4.4 per 100,000 respectively in 1994). It is also consistently higher among African-Americans than among whites (12.0 versus 6.1 per 100,000 respectively in 1994) (NCI, 1998), and is particularly high among African-American males (NCI, 1998).[2] For example, in the oldest age group of 85 years and up the general population rate was 79.4 per 100,000, whereas among African-American males it was 225.2 per 100,000.

The disproportionate occurrence of stomach cancer in males and African-Americans may be an important consideration when environmental equity

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[2] The National Cancer Institute (NCI) data presented in this chapter are based on invasive cancer, which comprises greater than 99 percent of stomach cancers (NCI, 1998).

issues are evaluated. As noted above, the cause of the increased rate of stomach cancer among men and African-Americans is not known. It may be due to dietary, environmental, genetic, or other factors. In the absence of causal data, it is reasonable to assume that the cause could be genetic and that the increase in risk would be reflected in higher than average medical costs and lives lost among males and African-Americans exposed to a pollutant that causes stomach cancer. Issues related to susceptible subgroups in benefits assessments are discussed in the Chapter I.1 section titled "Susceptible Subgroups."

Link to Chapter I.1

The number of stomach cancer patients in the U.S. is relatively small and the NCI cohort was also relatively small. Consequently the rates in the younger age ranges (where the numbers are exceedingly small) are somewhat erratic due to the high variability of estimates based on small sample sizes. However, the data show a clear progression of increased incidence over the ages and a consistent pattern of higher risk among African-Americans than whites and males than females.

Section II.2.D.2 presents the results of a sensitivity analysis for stomach cancer among African-American males. The analysis uses the higher incidence rates observed among African-American males to estimate the medical costs for this subgroup. The analysis raises complicated issues in evaluating high-risk subgroups. In addition, this analysis evaluates costs per stomach cancer patient and so does not reflect the additional costs to society of the likely higher risks that would be incurred in an African-American versus non-African-American population. These issues must be dealt with by risk assessors in calculating the number of cases. It may also be important to evaluate the disproportionate impact of environmental stomach cancer risk factors on this population subgroup and the benefits that would result for them from reducing pollution exposures.

II.2.A.4　　Treatment and Services

Initial diagnosis may include gastrointestinal (GI) imaging, blood tests, endoscopy, biopsy, computed tomography (CT) scans and laparoscopy. Treatment includes surgery, chemotherapy, irradiation, and other general medical services. Terminal care is eventually provided to most stomach cancer patients due to the high mortality rate for this cancer. This care may include a variety of services, including palliative surgery, drug therapy, home visits, psychological counseling, and other medical care (Gunderson et al., 1995).

II.2.A.5   Prognosis

II.2.A.5.1   Background
The overall prognosis for stomach cancer patients is poor, with approximately 80 to 85 percent of patients dying of the disease within ten years. Most deaths (over 90 percent) occur in the first four years, and approximately half of all patients die during the first year (NCI, 1998). Factors such as tumor size and location, histology, involvement of nodes, and the spread of cancer to other tissues affect outcome. Numerous new biochemical and immunological tests are used to provide additional information on the likely outcome. The importance of early detection and a confined tumor is evidenced by the greater than 90 percent survival rate among patients with a tumor confined to the mucosa or submucosa (Gunderson, 1995). However, few patients in the U.S. are diagnosed with stomach cancer at this early stage.

II.2.A.5.2   Relative Survival Rates (RSRs)
The NCI SEER data reports were accessed online to obtain information regarding mortality and survival probabilities and the duration after diagnosis until death (NCI, 1998). [3] These data are presented in this section because they relate to prognosis. Methods used to convert the NCI statistics to survival probabilities for stomach cancer patients, used in Section B to calculate medical costs, are discussed below.

The RSR is the number of observed survivors among patients, divided by the number of "expected" survivors among persons with the same age and gender in the general population (observed/expected). The RSR takes into account that there are competing causes of death that increase with age. The RSR for stomach cancer patients during the first year post-diagnosis is 46 percent. This value indicates that a person with stomach cancer would have, on average, a one-year survival probability that is 46 percent of someone of the same age and gender in the general population.

The RSRs provided by NCI for each year post-diagnosis are averages over all ages at diagnosis. RSRs are also provided for different ages at diagnosis, with five-year RSRs ranging from 19.0 to 21.8 percent (based on 1986-1993 data, NCI, 1998). (Five-year RSRs are the only form in which NCI provides RSRs that are specific to age at diagnosis.) Because RSRs are very similar across the ages at diagnosis for stomach cancer, relative survival rates are discussed without reference to the age at diagnosis.

An evaluation of the RSRs over the past 20 years indicates that they have increased overall through 1988, when they stabilized at approximately the same level through 1993 (the most recent year for which there are data).

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[33] The Website is http://www-seer.ims.mci.hin.gov

Based on this observation, the rates for 1988 through 1993 for the first through fifth years post-diagnosis were used in this analysis. It was necessary to use pre-1988 data to estimate survival beyond the fifth year. These longer-term survival data are from a period when RSRs were slightly lower. A very low rate of loss from stomach cancer exists after the first four years (generally less than two percent for the fifth and sixth years post-diagnosis, and less than one percent thereafter), so differences in survival in recent years will not have a substantial impact on costs. Ten years of data were used to estimate survival for the sixth through tenth years post-diagnosis to increase reliability because the number of stomach cancer deaths is very small during that period post-diagnosis.

II.2.A.5.3   Derivation of Survival and Mortality: Probabilities for Stomach Cancer Patients

The RSRs reported by NCI for each year post-diagnosis are based on a cohort followed over time. They are therefore *estimates* of the underlying population RSRs (i.e., the RSRs for the entire population of stomach cancer patients in the United States). A plot of the average RSRs for *n* years post-diagnosis (*n* = 1, 2, ..., 10) described above (Figure II.2-2) shows that the estimated RSRs follow a general exponential decay trend.

Figure II.2-2. Average Relative Survival Rates (RSR) for n Years Post-Diagnosis
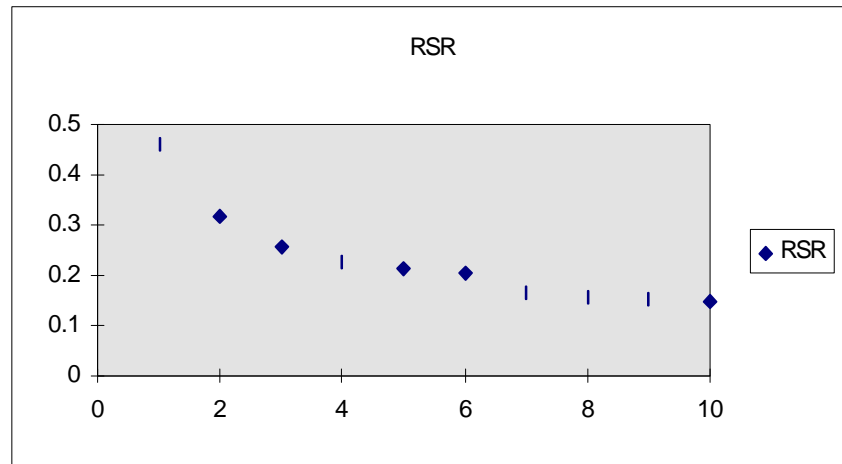
Rather than use these average estimated RSRs from NCI, which display some of the "bumpiness" that data often contain, the trend described by these RSRs was estimated by regression. The model that fit the data best was of the form:

$$\ln(RSR) = a + b \times \ln (Years\ Post{-}Diagnosis)\ .$$

The intercept (a) was estimated to be -0.78613 and the slope (b) was estimated to be -0.49508. The fit was excellent, with an R^2 of 0.985. Exponentiating the predicted natural logarithms of RSR yielded the predicted RSRs shown in Table II.2-2. A plot of the adjusted RSRs against years post-diagnosis (Figure II.2-3) shows the generally smooth trend.

Table II.2-2. Average RSRs* and Predicted (Adjusted) RSRs		
Years Post-Diagnosis (n)	Average RSR for n Years Post-Diagnosis	Adjusted (Predicted) RSR for n Years Post-Diagnosis
1	0.46	0.456
2	0.32	0.323
3	0.26	0.264
4	0.23	0.229
5	0.22	0.205
6	0.21	0.188
7	0.16	0.174
8	0.16	0.163
9	0.15	0.154
10	0.15	0.146
*The average RSR for n years post-diagnosis is the average of a set of RSRs reported by NCI (1998) for n years post-diagnosis as described in the text above.		

Figure II.2-3. Adjusted Relative Survival Rates (RSR) for n Years Post-Diagnosis
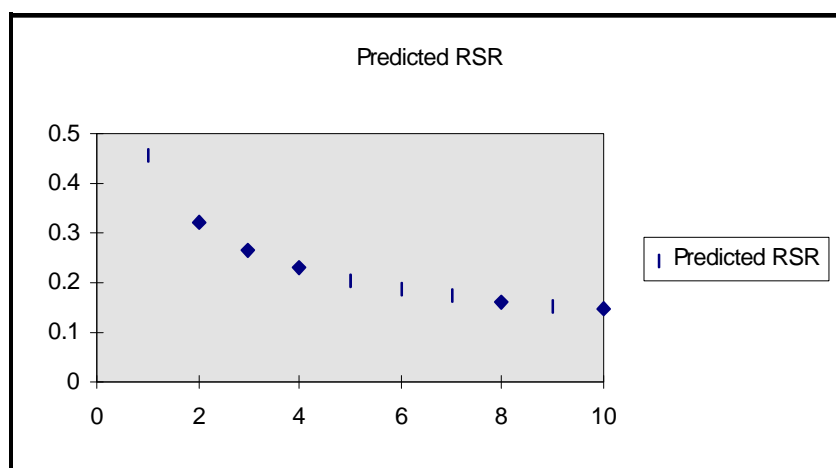
The adjusted RSRs shown in Table II.2-2 were used to derive survival probabilities for stomach cancer patients for each of the first ten years post-diagnosis. The RSR, which expresses the survival of patients in relation to the survival of the general population, can be converted to a survival probability for stomach cancer patients by using the population survival rate in the RSR equation:

$$RSR = \frac{observed\ survival\ rate\ among\ stomach\ cancer\ patients}{survival\ rate\ among\ age\text{-}\ and\ sex\text{-}matched\ cohort\ in\ the\ general\ population}$$

The RSR is designed to enable the analyst to derive the probability of dying specifically of the cancer of interest; this probability, however, is conditional on having not already died of something else. Using the definition of the RSR, it can be shown that 1 – RSR is the number in the cohort who were expected to survive but died (and are therefore presumed to have died of stomach cancer), divided by the number who were expected to survive. This value effectively takes the original cohort of stomach cancer patients and first subtracts those who die of other causes, then calculates the proportion of the remaining subset who die of stomach cancer specifically. This result is slightly different than the probability of dying of stomach cancer, given that one is diagnosed with it. This latter probability has the same numerator, but has as its denominator the entire original cohort of stomach cancer patients.

To obtain an estimate of the survival rate for stomach cancer patients to one-year post-diagnosis, the RSR for one-year post-diagnosis and the background survival rate for one year were used in the above equation. The survival rate for the general population at the average age at diagnosis (70 years) during their 70th year (from age 70 to 71) is 0.97326. The survival rate for stomach cancer patients to one-year post-diagnosis can be calculated using this value and the RSR of 46.15 for the first year post-diagnosis reported by NCI (1998) as follows:

$$46.15 = \frac{X}{0.97326}$$
$$(RSR)\quad (background\ rate)$$

$$X = 44.91\ (45\ percent)$$

This equation converts the RSR to a survival probability for stomach cancer patients. It tells us that among all persons diagnosed with stomach cancer, approximately 45 percent will survive the first year and 55 percent will die.

Although most stomach cancer patients die of the disease, some die of other causes. The probability of a stomach cancer patient dying of other causes is not the same as the probability of someone in the general population dying of other causes, particularly in the first few years post-diagnosis, when a stomach cancer patient's probability of dying of stomach cancer is quite high.[4] The probability of a stomach cancer patient dying of

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[4] This becomes clear in the extreme case in which the probability of dying of an illness is extremely high. Suppose, for example, that the probability of dying of all causes except for illness X is 0.025 in the general population. Suppose that in a cohort of patients diagnosed with illness X the probability of dying

stomach cancer and the probability of a stomach cancer patient dying of some cause other than stomach cancer in the nth year post-diagnosis, given survival to the nth year, were each derived from two known probabilities:

1)   the probability of a stomach cancer patient surviving through the nth year post-diagnosis, given survival to the nth year, and

(2)   the probability of dying of causes other than stomach cancer in a matched cohort in the general population.

The derivation is explained in detail in Appendix II.2-A at the end of this chapter.

Link to Appendix II.2-A

Each of the known probabilities depends on the number of years post-diagnosis and (minimally) on age at diagnosis. Consequently, separate probabilities were calculated for each year post-diagnosis and for each age at diagnosis considered in the analysis. They are shown for years one through ten post-diagnosis for someone diagnosed with stomach cancer at age 70 (the average age at diagnosis for stomach cancer) in Table II.2-3.

Using the probabilities in Table II.2-3, a hypothetical cohort of 100,000 stomach cancer patients diagnosed at age 70 was followed for ten years after diagnosis. For each year post-diagnosis, the analysis calculated the number of stomach cancer patients who:

1)   survive through the year,
2)   die of stomach cancer during the year, and
3)   die of some other cause during the year.

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from illness X in the first year post-diagnosis is 0.99. If the probability of dying of other causes in this cohort were the same as in the general population (0.025), then their probability of dying would be greater than 1.0.

Table II.2-3. Probabilities of Survival and Mortality for a Stomach Cancer Patient Diagnosed at Age 70

| Years post-diagnosis (n) | A Matched Cohort in the General Population | | A Cohort of 100,000 Stomach Cancer Patients | | | | | |
| | Probability of surviving n years | Probability of dying in nth year of causes other than stomach cancer, given survival to the nth year[a] | (Adjusted) Relative Survival Rate[b] | Probability of surviving n years post-diagnosis ((2)*(4)) | Number surviving through the nth year (100,000*(5)) | Probability of surviving through the nth year, given survival to the nth year ($(6)_n/(6)_{n-1}$) | Probability of dying of stomach cancer in the nth year, given survival to the nth year[b] | Probability of dying of other causes in the nth year, given survival to the nth year[c] |
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0	1.000	---	---	---	100,000	---	---	---
1	0.973	0.026	0.456	0.4434	44,342	0.4434	0.5373	0.0193
2	0.945	0.029	0.323	0.3055	30,551	0.6890	0.2865	0.0245
3	0.915	0.031	0.264	0.2421	24,210	0.7925	0.1793	0.0283
4	0.884	0.034	0.229	0.2028	20,282	0.8378	0.1307	0.0315
5	0.852	0.037	0.205	0.1749	17,490	0.8624	0.1029	0.0347
6	0.817	0.040	0.188	0.1534	15,340	0.8771	0.0849	0.0380
7	0.782	0.043	0.174	0.1359	13,594	0.8862	0.0722	0.0416
8	0.745	0.047	0.163	0.1212	12,122	0.8917	0.0628	0.0455
9	0.707	0.051	0.154	0.1085	10,846	0.8948	0.0555	0.0497
10	0.667	0.056	0.146	0.0972	9,717	0.8959	0.0497	0.0544

[a]The probabilities in the general population of dying from stomach cancer are 0.000256 in the 70-74 year age group, and 0.000348 in the 75-79 year age group. The probabilities in column (3) were derived by subtracting these probabilities from the corresponding probabilities of dying from any cause in the nth year given survival to the nth year.
[b] From Table II.2-2.
[c] See Appendix to this chapter for derivation of these probabilities.

From these numbers, the probabilities of:

1)   surviving through the nth year,
2)   dying of stomach cancer during the nth year, and
3)   dying of other causes during the nth year

were derived. The probability of dying of stomach cancer in the nth year post-diagnosis, for example, is calculated as the number of stomach cancer patients who die of stomach cancer in the nth year post-diagnosis divided by the original number in the cohort (100,000). The analysis is shown in Table II.2-4. The probabilities of a stomach cancer patient (age 70 at diagnosis) surviving through each year post-diagnosis, dying of stomach cancer during each year, and dying of other causes during each year are given in columns (7), (8) , and (9), respectively, of Table II.2-4. The probabilities in columns (7), (8), and (9) of Table II.2-4 are used in Section II.2.B to calculate the expected medical costs of stomach cancer patients diagnosed at age 70.

Table II.2-4. Following a Cohort of 100,000 Stomach Cancer Patients (Diagnosed at Age 70) Over Ten Years: Derivation of Probabilities of Survival and Mortality

						Probabilities		
Years Post-Diagnosis (n)	Probability of Surviving n years post-diagnosis (column (5) of Table II.2-3)	Number Surviving through nth year $(100{,}000*(2))$	Number Dying in nth year $((3)_{n-1} - (3)_n)$	Number dying of stomach cancer in the nth year $((3)_{n-1}*(8)_n$ of Table II.2-3)	Number dying of other causes in the nth year $((3)_{n-1}*(9)_n$ of Table II.2-3)	Probability of surviving through the nth year $((2)_n)$	Probability of dying of stomach cancer in the nth year $((5)/100{,}000)$	Probability of dying of other causes in the nth year $((6)/100{,}000)$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0	---	100,000	---	---	---	---		
1	0.4434	44,342	55,658	53,730	1,928	0.4434	0.5373	0.0193
2	0.3055	30,551	13,792	12,704	1,088	0.3055	0.1270	0.0109
3	0.2421	24,210	6,341	5,476	864	0.2421	0.0548	0.0086
4	0.2028	20,282	3,928	3,165	763	0.2028	0.0317	0.0076
5	0.1749	17,490	2,792	2,087	705	0.1749	0.0209	0.0071
6	0.1534	15,340	2,150	1,485	665	0.1534	0.0149	0.0067
7	0.1359	13,594	1,746	1,108	638	0.1359	0.0111	0.0064
8	0.1212	12,122	1,472	854	618	0.1212	0.0085	0.0062
9	0.1085	10,846	1,276	673	602	0.1085	0.0067	0.0060
10	0.0972	9,717	1,129	540	590	0.0972	0.0054	0.0059

II.2.B   Costs of Medical Treatment and Services for Stomach Cancer Patients

II.2.B.1   Methodology

II.2.B.1.1   *Overview*

Treatment of stomach cancer may occur over a brief or extended period of time, and costs may be limited or substantial. There is no typical case because of individual differences in the stage of cancer at diagnosis, multiple treatment options, patient health and age, and other factors; however, average costs can be calculated. Stomach cancer has a relatively high mortality rate, as discussed in Section A. Approximately 82 percent of people with stomach cancer eventually die of the disease. As discussed in Chapter I.1 of this handbook, the medical costs of those who die of the disease are usually very different than for those who survive. Therefore, although the focus of this chapter is on the costs incurred by the average stomach cancer patient, survivors and nonsurvivors of stomach cancer are considered as separate groups for purposes of this analysis.

Link to I.1.D.2

A data search was conducted for information regarding medical costs associated with stomach cancer. In addition to a literature search, most federal agencies dealing with cancer and medical costs were contacted for information and the various federal databases were discussed with senior staff at these agencies. Very recent cost data were not located. However, current (1994) cancer data were obtained regarding incidence and survival, which were used in the cost calculations described below. The cost estimates presented in this are based primarily on the work of Baker et al. (1989) and on two sources of statistical data: the National Cancer Institute (1998) and Vital Statistics of the United States, 1993 (NCHS, 1997). These data were evaluated and used to calculate appropriate estimates of the direct medical costs due to stomach cancer.

II.2.B.1.2   *Medical Cost Data*
II.2.B.1.2.1   Sources

Medical cost data would ideally be obtained on current medical expenditures for a specific illness. Although data files are maintained by public and private sector sources, they are not readily available. In addition, to obtain reliable cost estimates it is necessary to evaluate very large databases of charges from a variety of sources, a method impractical for the development of this chapter. A review of the medical economics literature in 1997 did not identify very recent sources of cost estimates for stomach cancer. Baker et al. (1989) was previously used for other chapters of this handbook and has been used as the basis for the cost estimates in this chapter. Based on the 1997 review of the literature

carried out for the development of this chapter, there do not appear to be new treatment methods for stomach cancer that substantially alter either the medical costs or the survival rates. Consequently, the cost estimates presented in this chapter may be considered appropriate under most circumstances (e.g., regional costs may vary).

II.2.B.1.2.2   Baker et al.'s Cost Estimation Method

Baker et al. (1989) used the Continuous Medicare History Sample File (CMHSF) to estimate the per-patient average lifetime medical cost of treating stomach cancer based on data files from 1974 to 1981. They chose CMHSF because:

1)   it is a nationally representative sample of the Medicare population (five percent), covering over 1.6 million patients;
2)   it is longitudinal, dating from 1974 to 1981; and
3)   it captures the majority of medical expenses for each beneficiary.

Five Medicare files are included in the CMHSF, which cover:

1)   inpatient hospital stays,
2)   skilled nursing facility stays,
3)   home health agency charges,
4)   physicians' services, and
5)   outpatient and other medical services.[5]

Costs that were not included are outpatient prescription medications and nursing home care below the skilled level.

Because CMHSF provides no indication of initial diagnosis, Baker et al. assumed that disease onset occurred when a diagnosis of stomach cancer was listed on a hospitalization record following a minimum of one year without a stomach cancer diagnosis. This assumption is reasonable due to the high frequency of hospitalization associated with the disease (i.e. individuals diagnosed with stomach cancer would be hospitalized). Only patients with an initial diagnosis during the years covered by the database (1974-1981) were included.

Costs associated with stomach cancer were assigned to three post-diagnostic time periods:

•   initial treatment, during the first three months following diagnosis;
•   maintenance care, between initial and terminal treatment; and
•   terminal treatment during the final six months prior to death.

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[5] See Baker et al. (1989 and 1991) for further details. Baker et al. (1991) contains additional descriptive data regarding the database and methods used for the cost analysis; however, it does not contain cost data for stomach cancer.

As noted in Chapter I.1, the amount paid for service may differ from the actual medical costs because many insurers and federal programs either 1) pay only a portion of total costs or 2) pay more than actual costs to underwrite the care providers' losses due to underpayment from other sources. Baker et al. used provider charges, rather than Medicare reimbursements (which represent only a portion of most total charges), thus providing a more accurate cost estimate.

Link to Chapter I.1

To improve the accuracy of the cost estimates, Baker et al. included cost data on coinsurance, deductibles, and other cost components. They made four adjustments to the cost estimates calculated from the CMHSF. First, charges were added for skilled nursing facilities (SNFs) not covered by Medicare by multiplying the "length of stay" at an SNF (computed from admission and discharge dates) by the average daily SNF charge. Second, the annual Medicare Part B deductible of $60 was added to the reimbursed charges in the database. Third, since Medicare pays only 80 percent of physicians' charges, Baker et al. scaled these reimbursements to 100 percent of physicians' charges to better reflect social costs. Finally, they inflated all dollar values to 1984 dollars using the Medical Care component of the Consumer Price Index.

II.2.B.1.2.3   Cost Estimates by Treatment Period

Medical costs associated with the initial, maintenance, and terminal cancer care treatment periods were itemized in Baker et al., 1989 and are shown in Table II.2-5. To estimate the incremental costs, a co-morbidity cost of $2,988 per year from Baker et al. (1991) was used in this analysis. To account for costs of other medical services anticipated to occur while the patient was receiving cancer treatment (i.e., co-morbidity/background costs), the co-morbidity cost was pro-rated for this analysis using the specified durations for the initial (three-month) and terminal (six-month) treatment periods. These costs are listed in Table II.2-5 with the incremental costs calculated for the three treatment periods. Total costs are reported for the initial and terminal care periods. Annual costs for the maintenance period are shown and are further discussed in the "Lifetime Costs" section below. Using the Medical Care component of the Consumer Price Index (CPI-U), all costs are inflated to 1996 dollars (1984:1996 = 2.14).

Table II.2-5. Average Per Patient Costs for the Three Periods of Treatment for Stomach Cancer in 1996 dollars			
Treatment Period	**Cost[a]**	**Co-morbidity Charge[b]**	**Incremental Cancer Treatment Cost**
Initial (3 months)	$30,908	$1,599	$29,309
Maintenance (per year)	$16,949	$6,394	$10,554
Terminal (6 months)	$34,522	$3,197	$31,325
a. From Baker et al. (1989 and 1991) adjusted using the Medical Care component of the Consumer Price Index (CPI-U) 1984:1996 = 2.14. b. Annual co-morbidity charges are $6,394 and were pro-rated for the duration of the treatment period.			

II.2.B.1.3 Calculation of Lifetime Cost Estimates for Stomach Cancer Patients

Although Baker et al. provide useful cost estimates for the three treatment periods, they do not provide information on two critical aspects of medical costs:

1) costs for survivors versus nonsurvivors of stomach cancer. These may differ substantially. For example, survivors would not have terminal care costs and may receive maintenance services for an extended time period.

2) estimates of the duration of the maintenance periods.

Data regarding age at diagnosis of stomach cancer were obtained from NCI (1998). Survival and mortality probabilities for each year post-diagnosis were derived from relative survival rates obtained from NCI (1998), as discussed in Section II.2.A.5.3. This information was used to address many time-related medical cost issues. For some aspects of the analysis, however, detailed information was not available, and average values have been used as a reasonable approximation (e.g., a ten-year maintenance period was assumed for survivors of stomach cancer). When average values or other assumptions are used in this analysis, they are so noted.

Link to Section II.2.A.5.3

As previously noted, there are not substantial differences in survival related to age at diagnosis, and NCI does not provide age-specific relative survival rates for each year post-diagnosis. Consequently, it was assumed for this analysis that the relative survival rates for stomach cancer were the same for all ages. The survival and mortality probabilities for stomach cancer patients, which are incorporated into calculations of expected medical costs, are based on this assumption.

There is also a lack of information on age-specific medical costs incurred by stomach cancer patients during the three treatment periods defined by Baker et al. Because of this, any differences in expected medical costs for stomach cancer patients diagnosed at different ages, based on current information, would differ only because of differences in survival and mortality probabilities. The discussion here focuses on the costs incurred by stomach cancer patients diagnosed at age 70 (the average age at diagnosis); a summary table of expected medical costs for patients diagnosed at several different ages is presented in the "Results" section for comparison.

The analysis assumes that death always occurs midyear. All stomach cancer patients are therefore assumed to incur the costs of initial treatment during the first three months of the illness. The costs incurred after that during the first year depend on whether the patient (1) survives through the year, (2) dies of stomach cancer during the year, or (3) dies of some other cause during the year. Patients who survive through the year incur the costs of initial treatment ($29,309) during the first three months, and then incur nine months' worth of maintenance care costs ($0.75 \times \$10,554 = \$7,916$) during the remainder of the year. The total cost incurred during the first year by those patients who survive the year is therefore $\$29,309 + \$7,916 = \$37,225$. Stomach cancer patients who die of stomach cancer during the first year incur the initial treatment cost and then incur terminal care costs for the remaining three months of their lives (because those who die are assumed to die midyear). Total costs during the first year post-diagnosis in this case are therefore $\$29,309 + 0.5 \times \$31,325 = \$44,972$.

Finally, the small percentage of stomach cancer patients who die of causes other than stomach cancer during the first year post-diagnosis incur the initial treatment costs and then incur three months' worth of maintenance care costs. Total first-year costs for these patients are therefore $\$29,309 + 0.25 \times \$10,554 = \$31,948$.

The expected medical costs for stomach cancer patients during the first year post-diagnosis, then, may be expressed as:

> **Expected First-Year Cost: initial treatment costs + [maintenance care costs for nine months × probability of survival through first year + terminal care costs for three months × probability of dying of stomach cancer during first year + maintenance care costs for three months × probability of dying of other causes during the first year]**

For each subsequent year, costs consist entirely of maintenance care costs for those who survive the year. For those who do not survive the year, costs depend on whether death was due to stomach cancer or other causes. For those who die of stomach cancer during the nth year, costs incurred

that year consist of six months of terminal care costs, or $31,325. For those who die of other causes during the nth year, there are six months of maintenance care costs, or $0.5 \times \$10,554 = \$5,277$.

The expected medical costs for stomach cancer patients during the nth year post-diagnosis, for $n>1$, then, may be expressed as:

Expected nth Year ($n>1$) Cost: [maintenance care cost for one year × probability of survival through nth year + terminal care cost for six months × probability of dying of stomach cancer during the nth year + maintenance care cost for six months × probability of dying of other causes during the nth year]

Expected Lifetime cost =

Expected First-Year cost + the sum of the (discounted) expected subsequent-year costs

The first year of treatment is calculated differently from other years because the first three months of that year are spent in "initial" treatment and the costs for that period of intensive medical care and surgery are calculated separately. The mathematical equation for the expected lifetime medical costs incurred by a stomach cancer patient over a ten-year period is:

$$\$29,309 + (\$10,554 \times 0.75 \times ps_1) + (\$10,554 \times 0.25 \times pm_1^{\,o}) + (\$31,325 \times 0.5 \times pm_1^{\,sc})$$

$$+\sum_{y=2}^{10}\left[\left(ps_y \times \frac{\$10,554}{(1+r)^{y-1}}\right) + \left(pm_y^{\,o} \times \frac{\$5,277}{(1+r)^{y-1}}\right) + \left(pm_y^{\,sc} \times \frac{\$31,325}{(1+r)^{(y-1)}}\right)\right]$$

where:
y = the year post-diagnosis
ps = the probability of surviving through the year,
pm^{sc} = the probability of dying of stomach cancer during the year
pm^{o} = the probability of dying from other causes during the year,
r = the discount rate

Example: Expected first-year medical costs of a stomach cancer patient diagnosed at age 70

As noted above, all stomach cancer patients incur an initial treatment cost of $29,309. Those who survive through the year (44.3 percent of those

diagnosed at age 70) also incur maintenance care costs for the remaining three quarters of the year. The total first-year costs of those who survive the year are:

Initial treatment:	$29,309
Maintenance treatment:	$7,916 (.75 × $10,554)
Total First-Year Cost	$37,225

More than half of stomach cancer patients (53.7 percent of those diagnosed at age 70) will die of stomach cancer during the first year. Those who do will incur the initial treatment costs plus half of the terminal care costs. The total first year costs of those who die of stomach cancer during the year are:

Initial treatment:	$ 29,309
Terminal care:	$15,663 (.50 × $31,325)
Total First-Year Cost	$44,972

Finally, a few stomach cancer patients (1.9 percent of those diagnosed at age 70) will die of competing illnesses during the first year. Because those who die of causes other than stomach cancer are assumed to die at the midpoint of the year, costs during the first half of the year are assumed to consist of the initial treatment costs for three months, plus three months of maintenance care costs as follows:

Initial treatment:	$29,309
Maintenance treatment:	$2,639 (.25 × $10,554)
Total First-Year Cost	$31,948

The expected first year medical cost incurred by a stomach cancer patient diagnosed at age 70 is just a weighted average of the costs of those who survive the first year, those who die of stomach cancer during the first year, and those who die of other causes during the first year, where the weights are the probabilities of each of these occurrences (see Table II.2-4):

$37,225 × 0.443 + $44,972 × 0.537 + $31,948 × 0.019 = $41,286

The weighted average medical cost calculations were carried out for ten years and expected costs were summed over all years from diagnosis to year ten. This was assumed to be a reasonable period over which additional medical costs associated with stomach cancer (i.e. maintenance care costs) would be incurred by stomach cancer patients. In reality, there may be follow-up care and continued testing over a longer period;

however, no data were available regarding those costs. They would certainly be less than $10,554 per year.

II.2.B.2 Results

II.2.B.2.1 Lifetime Cost Estimates for Survivors and Nonsurvivors Combined

The cost estimates for each year post-diagnosis and the estimate of expected total cost for a ten-year period are shown in Table II.2-6 for stomach cancer patients whose age of onset is 70 (the average age at diagnosis for this cancer). The discounted results are shown in the "Results" section which follows. The survival and mortality probabilities necessary for the calculations are shown in columns (2), (3) and (4) (and were taken from Table II.2-4). The cost components used in the calculations are shown in columns (5), (6), and (7).

II.2.B.2.2   Lifetime Cost Estimates for Stomach Cancer Survivors and Nonsurvivors Separately

II.2B.2.2.1   Overview

There are differences in medical services provided to stomach cancer patients who survive the disease (survivors) versus those who die of the disease (nonsurvivors). Based on cost estimates by Baker et al. (1989), terminal care is provided for approximately six months to terminally ill cancer patients. The costs to nonsurvivors for this care ($31,325) is considerably higher than costs for survivors who receive maintenance care for the same period of time ($5,277).[6]   EPA may use the value of a statistical life for nonsurvivors, and thus separate costs for survivors and nonsurvivors were calculated. The method to calculate costs for all patients described in Section II.2.B.1.3 uses the unconditional probabilities of survival and mortality given in Table II.2-4. The method used to calculate costs for survivors and nonsurvivors separately requires the conditional probabilities of survival and mortality in each group — that is, the probabilities conditional on being a stomach cancer survivor or being a stomach cancer nonsurvivor.

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[6] Nonsurvivors include only those who die of stomach cancer and do NOT include those who die of any other causes.

Table II.2-6. Expected Costs of Medical Services (in 1996$) for Stomach Cancer Patients (Age of Onset = 70)

Years Post-Diagnosis (n) (1)	Probabilities[a]: of surviving through the nth year (2)	of dying of stomach cancer in the nth year (3)	of dying of other causes in the nth year (4)	Medical Costs in the nth Year (undiscounted) if survive through the nth year (5)	if die of stomach cancer in the nth year (6)	if die of other causes in the nth year (7)	Expected Medical Costs for the nth Year Post-Diagnosis ((2)×(5)+(3)×(6)+(4)×(7))
1[b]	0.4434	0.5373	0.0193	$37,225	$44,972	$31,948	$41,286
2	0.3055	0.1270	0.0109	$10,554	$31,325	$5,277	$7,261
3	0.2421	0.0548	0.0086	$10,554	$31,325	$5,277	$4,316
4	0.2028	0.0317	0.0076	$10,554	$31,325	$5,277	$3,172
5	0.1749	0.0209	0.0071	$10,554	$31,325	$5,277	$2,537
6	0.1534	0.0149	0.0067	$10,554	$31,325	$5,277	$2,119
7	0.1359	0.0111	0.0064	$10,554	$31,325	$5,277	$1,815
8	0.1212	0.0085	0.0062	$10,554	$31,325	$5,277	$1,579
9	0.1085	0.0067	0.0060	$10,554	$31,325	$5,277	$1,387
10	0.0972	0.0054	0.0059	$10,554	$31,325	$5,277	$1,226
Expected Total Cost Through the 10th Year Post-Diagnosis for a Stomach Cancer Patient Diagnosed at Age 70:							$66,700

a. The probabilities listed in this table are from Table II.2-4. The costs are listed in Table II.2-5.
b. First year costs include the charge for "initial" therapy ($29,309). The duration of maintenance care is adjusted accordingly (see text for discussion).

Probabilities of survival were calculated using data shown in Table II.2-4. Summing the entries in column (5) of Table II.2-4, 81,822 of the 100,000 stomach cancer patients diagnosed at age 70 (or about 82 percent) die of stomach cancer within ten years. The remainder (100,000 - 81,822 = 18,178) are survivors of stomach cancer. The probabilities of a stomach cancer patient diagnosed at age 70 surviving stomach cancer and dying of stomach cancer are therefore estimated to be 0.182 and 0.818 (about 0.18 and 0.82), respectively.

Link to Table II.2-4

The conditional probability of a stomach cancer nonsurvivor dying in the nth year is just the number of stomach cancer patients who die of stomach cancer during the nth year (from column (5) of Table II.2-4) divided by the total number of stomach cancer nonsurvivors. For example, the conditional probability of a stomach cancer nonsurvivor dying during the first year post-diagnosis is 53,730/81,822 = 0.657. Similarly, the conditional probability of a stomach cancer survivor dying (of other causes) in the nth year is just the number of stomach cancer patients who die of other causes during the nth year (from column (6) of Table II.2-4) divided by the total number of stomach cancer survivors. For example, the conditional probability of a stomach cancer survivor dying of some other cause during the first year post-diagnosis is 1,928/18,178 = 0.106. The conditional probabilities of survival and mortality for survivors and nonsurvivors of stomach cancer are given in Table II.2-7.

Table II.2-7. Conditional Probabilities of Survival and Mortality for Survivors and Nonsurvivors of Stomach Cancer (Age of Onset = 70)

| Years Post-Diagnosis (n) | Stomach Cancer Survivors | | Stomach Cancer Nonsurvivors | |
| | Conditional probability of: | | Conditional probability of: | |
	Surviving through the nth year	Dying of some other cause during the nth year	Surviving through the nth year	Dying of stomach cancer during the nth year
1	0.894	0.106	0.343	0.657
2	0.834	0.060	0.188	0.155
3	0.787	0.048	0.121	0.067
4	0.745	0.042	0.082	0.039
5	0.706	0.039	0.057	0.026
6	0.669	0.037	0.039	0.018
7	0.634	0.035	0.025	0.014
8	0.600	0.034	0.015	0.010
9	0.567	0.033	0.007	0.008
10	0.535	0.032	0.000	0.007

II.2.B.2.2.2. Lifetime Cost Estimates for Stomach Cancer Survivors

As shown in Table II.2-5, all stomach cancer patients will incur initial treatment costs ($29,309) during the first three months of the first year post-diagnosis. If they survive the first year, they will also incur nine months worth of maintenance care costs (0.75 × $10,554 = $7,916) that first year. The total cost incurred during the first year by those stomach cancer survivors who survive the first year is therefore $29,309 + $7,916 = $37,225.

Link to Table II.2-5

Stomach cancer survivors who die of some other cause during the first year incur the initial treatment costs during the first three months and then incur three months (25 percent) of maintenance care costs (because they are assumed to die midyear), for a total cost of $29,309 + 0.25 × $10,554 = $31,948.

The expected medical costs for stomach cancer survivors during the first year post-diagnosis may therefore be expressed as:

> **Expected First-Year Cost: initial treatment costs + [maintenance care costs for nine months × probability of survival through first year + maintenance care costs for three months × probability of dying of other causes during the first year]**

For each subsequent year, costs consist entirely of maintenance care costs for those who survive the year. For those who die of other causes during the year, there are six months of maintenance care costs, or 0.5 × $10,554 = $5,277.

The expected medical costs for stomach cancer survivors during the *n*th year post-diagnosis, for *n*>1, then, may be expressed as:

> **Expected *n*th Year (*n*>1) Cost: [maintenance care cost for one year × probability of survival through *n*th year + maintenance care cost for six months × probability of dying of other causes during the *n*th year]**

Expected Lifetime cost =

> **Expected first year cost + the sum of the (discounted) expected subsequent-year costs**

The calculations above use the conditional probabilities of patients who do not die of stomach cancer, shown in Table II.2-7.

Using the initial, maintenance, and terminal care costs from Table II.2-5, the mathematical equation for the lifetime costs incurred by stomach cancer survivors is:

$$\$29,309 + pm_1{}^s \times 0.25 \, (\$10,554) + ps_1{}^s \times .75 \times \$10,554$$

$$+ \sum_{y=2}^{10} \left[ps_y{}^s \, \frac{\$10,554}{(1 + r)^{y-1}} + pm_y{}^s \, \frac{\$5,277}{(1 + r)^{y-1}} \right]$$

where: y = the year post-diagnosis

ps^s = the conditional probability of survival for that year, conditional on being a survivor of stomach cancer

pm^s = the conditional probability of mortality for that year, conditional on being a survivor of stomach cancer

r = the discount rate.

The expected medical costs for stomach cancer survivors for each year post-diagnosis, as well as the expected total medical costs over ten years post-diagnosis are shown in Table II.2-8.

II.2.B.2.2.3   Lifetime Cost Estimates for Stomach Cancer Nonsurvivors

Nonsurvivors of stomach cancer will incur initial, maintenance, and terminal costs. Their lifetime medical costs associated with the disease can be calculated from the costs per treatment period shown in Table II.2-5 and the conditional probabilities for nonsurvivors of stomach cancer shown in Table II.2-7.

Link to Table II.2-5 and II.2-7

As Table II.2-7 indicates, most stomach cancer patients who die of stomach cancer die in the first few years post-diagnosis. About 80 percent die in the first two years. Deaths from stomach cancer after the first four years are minimal. As with stomach cancer survivors, medical costs for nonsurvivors each year post-diagnosis were calculated as a weighted average of the costs incurred by those who survive the year and those who die (of stomach cancer) during the year.

Table II.2-8. Expected Costs of Medical Services (in 1996$) for Survivors of Stomach Cancer (Age of Onset = 70)					
Years Post-Diag-nosis (n)	Medical Costs Through the 10th Year Post-diagnosis[a] (undiscounted)				
	Medical Cost if Survive Through the nth Year (1)	Conditional Probability of Survival Through the nth Year[b] (2)	Medical Cost if Die of other Causes in the nth Year (3)	Conditional Probability of Mortality in the nth Year[b] (4)	Total Cost Based on Weighted Average[c] = (1)×(2) + (3)×(4)
1[d]	$37,225	0.894	$31,948	0.106	$36,666
2	$10,554	0.834	$5,277	0.060	$9,119
3	$10,554	0.787	$5,277	0.048	$8,553
4	$10,554	0.745	$5,277	0.042	$8,080
5	$10,554	0.700	$5,277	0.039	$7,654
6	$10,554	0.669	$5,277	0.037	$7,257
7	$10,554	0.634	$5,277	0.035	$6,878
8	$10,554	0.600	$5,277	0.034	$6,514
9	$10,554	0.567	$5,277	0.033	$6,159
10	$10,554	0.535	$5,277	0.032	$5,813
Expected Total (Undiscounted) Cost Through the 10th Year Post-Diagnosis:					$102,693

a. Costs are based on data reported in Table II.2-5, adapted from Baker et al., 1989.
b. Probabilities of survival and mortality, taken from Table II.2-7, are conditional on surviving stomach cancer.
c. Weighted average of the costs incurred by survivors who survive the year and the costs incurred by survivors who die of other causes during the year. Weighting is based on the conditional probabilities listed.
d. Costs during the first year include a charge for "initial" therapy ($29,309), and the duration of maintenance or terminal care is adjusted accordingly. See text for discussion.

It was assumed that those who die during a year receive six months of care (as was done for the survivors above). It was also assumed that terminal care lasting six months would be provided to all nonsurvivors. Therefore, unless death occurred during the first year, when initial care was assumed to occur, the care costs which were assigned to the last year of life were terminal costs. If death occurred during the first year post-diagnosis, it was assumed that initial care and three months (half of the total) of terminal care were provided.

The general description of medical costs for nonsurvivors may be expressed as:

Expected cost for each year post-diagnosis =

> **Expected First-Year Cost:** **[initial costs + half the terminal costs] × probability of mortality during the first year + [initial costs + maintenance care costs for nine months] × probability of survival for first year**

> **Expected nth Year ($n>1$) Cost:** **maintenance care cost for one year × probability of survival through nth year + terminal costs × probability of mortality in nth year**

Expected Lifetime cost =

> **Expected First-Year cost + the sum of the (discounted) expected subsequent-year costs**

As with the cost calculations for stomach cancer survivors, the probabilities used in these cost calculations are the conditional probabilities given in Table II.2-7, which are conditional on dying of stomach cancer.

Using the initial, maintenance, and terminal care costs from Table II.2-5, the mathematical equation for the expected lifetime costs incurred by nonsurvivors is:

$$\$29{,}309 \; + \; pm_1^{ns} \; \times \; 0.5 \; (\$31{,}325) \; + \; ps_1^{ns} \; \times \; .75 \; \times \; \$10{,}554$$

$$+ \sum_{y=2}^{10} \left[ps_y^{ns} \; \frac{\$10{,}554}{(1 \; + \; r)^{y-1}} \; + \; pm_y^{ns} \; \frac{\$31{,}325}{(1 \; + \; r)^{y-1}} \right]$$

where: y   =   the year post-diagnosis

    ps^{ns} =   the conditional probability of survival for that year, conditional on being a nonsurvivor of stomach cancer

    pm^{ns} =   the conditional probability of mortality for that year, conditional on being a nonsurvivor of stomach cancer

    r   =   the discount rate.

The costs are summed over all years from diagnosis to death. Maintenance care costs are not added in the last year of life because during the six months that are assumed to constitute this period the patient is assumed to receive terminal care. (The discounted results are shown in the "Results" section that follows.)

<u>Example: Nonsurvivors Year One</u>

During the first year post-diagnosis, nonsurvivors of stomach cancer who survive the year (34.3 percent) will, on average, incur the following costs:

Initial treatment:	$29,309
Maintenance treatment:	$7,916 (.75 × $10,554)
Total Cost	$37,225

However, 65.7 percent of stomach cancer nonsurvivors will die during the first year. Those individuals are assumed to die at the midpoint of the year (to obtain an average survival for the time period and average costs). That group will incur the initial costs for three months, plus three months of terminal care as follows:

Initial treatment:	$29,309
Terminal care:	$15,663 (.5 × $31,325)
Total Costs:	$44,972

A weighted average of the first-year costs incurred by stomach cancer nonsurvivors who do and do not die during the first year was calculated as follows:

$$\$37,225 \times 0.343 + \$44,972 \times 0.657 = \$42,312$$

During the second and subsequent years up to but not including the year of death, the medical costs of nonsurvivors will include the costs of maintenance care. As noted above, the last year of life is composed of

terminal care costs only, since all patients are assumed to receive six months of terminal care. For example, if someone died during the third year post-diagnosis, he would receive three months of initial care and nine months of maintenance care during the first year; he would receive 12 months of maintenance care during the second year; and he would receive terminal care for the six months that he is assumed to have survived during the third year (as noted previously, all patients are assumed to die mid-year to obtain average cost estimates for a year).

When the costs for each year are summed over a period of ten years post-diagnosis, during which essentially all patients who will die of stomach cancer have done so, the total cost per nonsurvivor is obtained. These costs are shown in Table II.2-9.

II.2.B.2.3 A Comparison of the Expected Medical Costs of Stomach Cancer Patients, Using Two Approaches

Section II.2B.1.3 discusses calculation of the average direct medical costs for all patients (average costs) and Section II.2.B.1.4 provides separate cost estimates for survivors and nonsurvivors of stomach cancer. The average patient cost can be calculated, however, from the results in II.2B.1.4 using the weighted average of the expected costs of stomach cancer survivors and nonsurvivors, where the weights are the probabilities of surviving stomach cancer and not surviving it, respectively.

As shown in Table II.2-6, the expected medical cost for ten years post-diagnosis for a stomach cancer patient diagnosed at age 70 is $66,700. The expected medical costs calculated separately for survivors and nonsurvivors of stomach cancer (for those diagnosed at age 70) are $102,693 and $58,704, respectively. The probability of being a stomach cancer survivor when onset occurs at age 70 is 0.18178; the probability of being a stomach cancer nonsurvivor is 0.81822. The expected cost incurred by a stomach cancer patient, calculated as a weighted average of the costs of those who survive stomach cancer and those who die from it, is therefore

$$\$102,693 \times 0.18178 \ + \ \$58,704 \times 0.81822 = \$66,700.$$

Link to Table II.2-6

This is the same value that was calculated by following a cohort of stomach cancer patients over the ten-year period, using their (unconditional) probabilities of survival, death from stomach cancer, and death from other causes for each year (shown in Table II.2-6).

	Table II.2-9. Expected Costs of Medical Services (in 1996$) for Nonsurvivors of Stomach Cancer (Age of Onset = 70)				
	Medical Costs Through the 10th Year Post-diagnosis[a] (undiscounted)				
Years Post-Diag-nosis (n)	Medical Cost if Survive Through the nth Year (1)	Conditional Probability of Survival Through the nth Year[b] (2)	Medical Cost if Die in the nth Year (3)	Conditional Probability of Mortality in the nth Year[b] (4)	Total Cost Based on Weighted Average[c] = (1)×(2) + (3)×(4)
1[d]	$37,225	0.343	$44,972	0.657	$42,312
2	$10,554	0.188	$31,325	0.155	$6,849
3	$10,554	0.121	$31,325	0.067	$3,375
4	$10,554	0.082	$31,325	0.039	$2,082
5	$10,554	0.057	$31,325	0.026	$1,400
6	$10,554	0.039	$31,325	0.018	$978
7	$10,554	0.025	$31,325	0.014	$691
8	$10,554	0.015	$31,325	0.010	$483
9	$10,554	0.007	$31,325	0.008	$327
10	$10,554	0.000	$31,325	0.007	$207
Expected Total (Undiscounted) Cost Through the 10th Year Post-Diagnosis:					$58,704

a. Costs are based on data reported in Table II.2-6, adapted from Baker et al., 1989.
b. Probabilities of survival and mortality, taken from Table II.2-7, are conditional on dying of stomach cancer within ten years post-diagnosis.
c. Weighted average of the costs incurred by nonsurvivors who survive the year and the costs incurred by nonsurvivors who die during the year. Weighting is based on the conditional probabilities listed.
d. Costs during the first year include an additional charge for "Initial" therapy ($29,309), and the duration of maintenance or terminal care is adjusted accordingly. See text for discussion.

II.2.B.2.4 Discounted Medical Costs for All Patients, Survivors, and Nonsurvivors

The per patient lifetime direct medical costs were calculated for stomach cancer patients (as shown in Table II.2-6), stomach cancer survivors (as shown in Table II.2-8) and stomach cancer nonsurvivors (as shown in Table II.2-9) diagnosed at age 70, undiscounted as well as using discount rates of three, five, and seven percent. The discounted costs for each year were discounted back to year one (time of diagnosis). This procedure was carried out for ten years following diagnosis (which, for nonsurvivors, comprises the full duration of treatment time because virtually all patients that are going to die of stomach cancer do so within ten years) and comprises the assumed full duration of maintenance care for survivors. The results are shown in Table II.2-10.

Table II.2-10. Costs of Medical Services (in 1996$) for Stomach Cancer Patients, Survivors, and Nonsurvivors (Diagnosed at Age 70) Undiscounted and Discounted at 3, 5, and 7 Percent				
	Discount Rate			
Patient Group	**Undiscounted**	**3**	**5**	**7**
Survivors	$102,693 ($102,700)	$94,229 ($94,200)	$89,749 ($89,700)	$85,654 ($85,700)
Nonsurvivors	$58,704 ($58,700)	$57,524 ($57,500)	$56,826 ($56,800)	$56,190 ($56,200)
Average Patient	$66,700 ($66,700)	$64,229 ($64,200)	$62,811 ($62,800)	$61,546 ($61,500)
* The costs in parenthesis have been rounded to the nearest hundred dollars.				

II.2.C.   Sensitivity Analyses

The calculation of expected medical costs incurred by a stomach cancer patient depends on several input factors, including treatment methods, survival percentages and durations, and the age of diagnosis. To illustrate the sensitivity of medical costs to key demographic characteristics, sensitivity analyses were carried out for age at diagnosis and for a sex and race combination. Age at diagnosis was selected because environmental pollutants may cause cancer to occur at earlier ages than the ages at which these cancers typically occur. Many chemicals studied in controlled animal cancer evaluations cause cancer at earlier ages than the ages at which cancer "spontaneously" occurs in the animals. This same dynamic has been observed among occupationally-exposed workers whose cancer results from exposures to chemicals and radiation. For example, many studies of radon and lung cancer indicate that radon-associated lung cancer occurs at

younger ages than would be expected in the general population. A sensitivity analysis of African-American males was conducted because this is a large high-risk group in the United States.

II.2.C.1   The Effect of Age at Diagnosis on Medical Costs

Expected medical costs incurred by stomach cancer patients, stomach cancer survivors, and stomach cancer nonsurvivors were calculated for ages at diagnosis of 22, 42, 52, 62, 70, and 82. For each age at diagnosis, the methods used to calculate expected medical costs were the same as those used when age at diagnosis is 70. These methods are discussed in Section II.2.B and are illustrated using:

- age at diagnosis equal to 70 in Table II.2-6 for expected medical costs incurred by stomach cancer patients;

- Tables II.2-8 and II.2-9 for expected medical costs incurred by survivors and nonsurvivors, respectively;

Link To Tables II.2-6 ,8 ,9

There is no information on age-specific medical costs comprising initial treatment, maintenance care, or terminal care (the three treatment phases delineated by Baker et al. (1989)); however, costs would not be expected to vary substantially by age. In addition, the relative survival rates obtained from NCI (1998) are not age-specific. Consequently, differences in expected medical costs across different ages at diagnosis are based solely on differences in age-specific survival and mortality probabilities in the general population. The results of the age-specific analysis are shown in Table II.2-11.

Table II.2-11. Summary Table of Expected Medical Costs Incurred by Stomach Cancer Patients, Survivors, and Nonsurvivors, by Age at Diagnosis			
Age at Diagnosis	**(Undiscounted) Expected Medical Costs for 10 Years Incurred by a Stomach Cancer:**		
	Patient	**Survivor**	**Non-survivor**
22	$70,482	$130,789	$60,077
42	$70,227	$128,522	$59,987
52	$69,721	$124,298	$59,804
62	$68,479	$114,569	$59,360
70*	**$66,700**	**$102,693**	**$58,704**
82	$61,581	$77,086	$56,798
* This is the average age used in the main analysis and is included as a point of reference for this sensitivity analysis.			

As can be seen in Table II.2-11, differences in expected medical costs across ages at diagnosis are greater among survivors than nonsurvivors. This may be an artifact of several characteristics of the analysis, in which medical costs and relative survival rates were not age-specific and a survivor's cost of surviving through the year is twice what it is if death from some other cause occurs during the year. Younger stomach cancer survivors have a greater chance of not dying of other causes during each year than older stomach cancer survivors, based simply on age-specific general population survival rates. Stomach cancer survivors who survive through a year incur twice the cost of those who die of other causes during the year (a full year's worth of maintenance care cost versus half a year's worth of maintenance care cost). Because of this, younger survivors, whose survival probabilities are greater than older survivors, incur substantially more costs.

II.2.C.2   The Effect of Race on Medical Costs: An Analysis of African-American Males

II.2.C.2.1   Incidence of Stomach Cancer

Of the four gender-race categories for which NCI (1998) provides information related to stomach cancer (white males, white females, African-American males, African-American females), the group with the highest rates of stomach cancer is African-American males. A comparison of incidence rates at the different ages at diagnosis for the general U.S. population versus African-American males is given in Table II.2-12.

Table II.2-12. Stomach Cancer Incidence Rates for the General U.S. Population Versus African-American Males

Age at Diagnosis	Incidence per 100,000		Ratio of Incidence Rates (general population/African-American Males)
	General U.S. Population	African-American Males	
0-4	0.0	0.0	----
5-9	0.0	0.0	----
10-14	0.0	0.0	----
15-19	0.1	0.0	0.00
20-24	0.1	0.7	7.00
25-29	0.4	0.2	0.50
30-34	0.7	1.7	2.43
35-39	1.5	3.5	2.33
40-44	2.7	8.1	3.00
45-49	4.4	10.0	2.27
50-54	8.3	22.5	2.71
55-59	14.1	38.8	2.75
60-64	21.7	55.9	2.58
65-69	31.8	83.9	2.64

Table II.2-12. Stomach Cancer Incidence Rates for the General U.S. Population Versus African-American Males

Age at Diagnosis	Incidence per 100,000		Ratio of Incidence Rates (general population/African-American Males)
	General U.S. Population	African-American Males	
70-74	45.6	127.8	2.80
75-79	55.9	111.6	2.00
80-84	67.5	135.8	2.01
85+	79.4	225.2	2.84

Incidence rates for the earliest ages at diagnosis are probably unreliable because they are based on very small samples. Starting from about age 30, however, African-American males have an incidence rate of stomach cancer that is two to three times that of the general U.S. population. The cause of the increased rate of stomach cancer among African-Americans males is not known. It may be due to dietary, environmental, genetic, or other factors. Issues related to susceptible subgroups in benefits assessments are discussed in the Chapter I.1 section titled "Susceptible Subgroups."

Link to Chapter I.1

II.2.C.2.2   *Risk Versus Per Capita Costs*
Incidence rates that are two to three times higher than those of the general population suggest that exposure to pollutants associated with stomach cancer may result in expected costs-of-illness for African-American males that are two to three times higher *per exposed African-American male* as compared with the expected costs incurred by the average exposed individual in the general population. Suppose, for example, that stomach cancer costs $50,000 per stomach cancer patient on average. Suppose also that the incidence rate among African-American males is 84 per 100,000 while the incidence rate in the general population is 32 per 100,000. If the cost per patient is the same among African-American males as among individuals in the general population, then the expected cost of stomach cancer *per exposed African-American male* is

$$\$50,000 \times 0.00084 = \$42.$$

The expected cost of stomach cancer *per exposed individual in the general U.S. population* is

$$\$50,000 \times 0.00032 = \$16.$$

II.2.C.2.3. Comparison of Per Capita Costs: African-American Males versus the General U.S. Population

The costs of illness analyzed in this handbook are not costs per exposed individual, but rather costs *per patient (per capita)*, unlike the analysis above. This chapter estimates the expected costs incurred by an individual who has been diagnosed with stomach cancer. Even though disproportionately more African-American males are diagnosed with stomach cancer than the general population, their medical costs per patient may or may not be higher than those of stomach cancer patients in the general population. To contrast the costs of these two groups, the analyses that were carried out for the general U.S. population were also carried out for African-American males.

Although the methodology used for this sensitivity analysis was the same as that used in the main analysis, the values of the following inputs to the analysis were altered to be specific to the population of African-American males in the U.S.:

- age-specific survival rates,
- age-specific life expectancies,
- age-specific probabilities of dying specifically of stomach cancer, and
- RSRs for each year post-diagnosis.

RSRs were not available for African-American males for each year post-diagnosis. These were therefore derived by multiplying the adjusted RSRs used in the main analysis (see Table II.2-2) by the ratio of the five-year RSR for African-American males, 1986-1993 (16.9), to the corresponding five-year RSR for the general population (20.6).

Link to Table II.2-2

Given values for these input parameters specific to African-American males in the U.S., the expected per capita medical costs incurred by African-American male stomach cancer patients were calculated. The resulting medical costs is shown, and compared with the corresponding medical costs of the average patient in the general population, in Tables II.2-13.

Table II.2-13. Expected Medical Costs Over 10 Years for a Stomach Cancer Patient, Survivor, and Nonsurvivor for Selected Ages at Diagnosis: A Comparison Between the General U.S. Population and African-American Males

Age at Diagnosis	General U.S. Population Expected Medical Costs for 10 Years for a stomach cancer:			African-American Males Expected Medical Costs for 10 Years for a stomach cancer:		
	Patient	Survivor	Non-survivor	Patient	Survivor	Non-survivor
22	$70,482	$130,789	$60,077	$65,629	$127,517	$56,898
42	$70,227	$128,522	$59,987	$65,014	$121,002	$56,678
52	$69,721	$124,298	$59,804	$64,205	$113,390	$56,383
62	$68,479	$114,569	$59,360	$62,669	$100,569	$55,829
82	$61,581	$77,086	$56,798	$56,026	$65,150	$53,296
Average age at diagnosis for African-American males: 66	-----	-----	-----	$61,779	$94,397	$55,489
Average age at diagnosis in the general U.S. population: 70	$66,700	$102,693	$58,704	-----	-----	-----

Expected per capita medical costs of African-American male stomach cancer patients are uniformly less than the corresponding per capita costs for stomach cancer patients in the general U.S. population at all ages at diagnosis considered. The patterns are similar for stomach cancer survivors and nonsurvivors. As noted in Section II.2.C.1, Baker et al. (1989) do not report costs for any of the three treatment periods separately by age at diagnosis or by any other demographic characteristic. Differences in expected medical costs between African-American male stomach cancer patients (or survivors or nonsurvivors of stomach cancer) and their counterparts in the general population are therefore, in this analysis, due solely to differences in survival and mortality probabilities.

II.2.C.2.3.1 Survivors' Medical Costs

Among survivors of stomach cancer, costs beyond the first year consist only of maintenance care costs. The greater the probability of survival (i.e., of not dying of some other cause), the longer the expected period of maintenance care, and the greater the expected costs incurred by survivors. African-American males have notably *lower* survival rates (death rates are higher from non-stomach cancer causes) than the general population at each age. Consequently, the expected costs incurred by an African-American male survivor of stomach cancer are *lower* than the corresponding costs of a stomach cancer survivor from the general population. That is, at each age there is a smaller proportion of African-American males surviving to incur the costs of maintenance care as compared with stomach cancer survivors in the general U.S. population.

II.2.C.2.3.2 Nonsurvivors' Medical Costs

Among nonsurvivors of stomach cancer, costs beyond the first year are three times as high for those who die of stomach cancer during the year ($31,325) as for those who survive the year ($10,554). In the first year post-diagnosis, the cost differential between those who survive the year and those who die of stomach cancer during the year is much less than in subsequent years. This is because those who die are assumed to die midyear, and during the first three months of the first year stomach cancer patients are assumed to undergo initial treatment, leaving only three months (as opposed to the full six months) of expensive terminal care in the first year. Because a substantially larger percentage of African-American male nonsurvivors die during the first year post-diagnosis as compared with general population nonsurvivors, the overall costs incurred by African-American male nonsurvivors are estimated to be less than those incurred by general population nonsurvivors. This is to some extent due to the assumption that, if the patient dies of stomach cancer during the first year post-diagnosis, there are only three months of terminal care costs incurred.

II.2.D. Uncertainties and Limitations

As noted periodically in the above discussion, there is substantial uncertainty surrounding various aspects of cost in the analyses. Information concerning important inputs to the analysis was often limited to some degree and, in some cases, was highly limited. Although a complete uncertainty analysis is beyond the scope of this work, the significant sources of uncertainty are discussed below in Section II.2.D.1. The scope of the analysis had some limitations as well. These are discussed in Section II.2.D.2.

II.2.D.1. Uncertainties Surrounding Key Inputs to the Analysis

The cost estimates based on Baker et al. (1989, 1991) have a number of limitations, many of them noted by Baker et al. (1991) and Mor et al. (1990) and Mor (1993). Most of these limitations arise from the use of CMHSF. Medicare data has five limitations that decrease its value for calculating the average lifetime direct medical costs of treating stomach cancer. First, Medicare covers only medical services for most persons age 65 and over, disabled persons entitled to Social Security cash benefits for at least 24 months, and most persons with end-stage renal disease. All patients not covered by Medicare are excluded from the database, including all non-disabled women under 65, and women over 65 using private health insurance (Baker et al., 1991).

Given that diagnosis of stomach cancer occurs before age 65 in 28.7 percent of patients (NCI, 1998), the CMHSF excludes a significant number of younger patients. According to Mor et al., treatment for younger

women tends to be more intensive (and therefore more costly per unit time) than treatment for older women, though older women tend to have longer hospital stays. Because these differences counteract each other, the omission of younger women from the analysis is not expected to affect the results substantially. In addition, the majority of senior citizens are enrolled in Medicare (Ibid); differences in medical costs incurred by senior citizens not using Medicare should have little effect on overall cost estimates.[7]

Medicare also does not cover self-administered drugs, intermediate nursing care, long-term nursing care, and expensive, extraordinary treatments (such as bone marrow transplants). For some patients these may represent significant percentages of total treatment costs. Most direct medical costs, however, appear to be covered by the CMHSF database and are included in Baker et al.'s analysis.

Another drawback is that Baker et al. were not able to identify stomach cancer patients in CMHSF whose diagnosis and first course of therapy did not involve hospitalization. In an analysis of Rhode Island stomach cancer patients covered by Medicare, Mor et al. determined that approximately 13 percent of stomach cancer patients were initially diagnosed without hospitalization, and had substantially lower initial and subsequent treatment costs (Mor et al., 1990). This omission likely causes average treatment costs to be overestimated, though by relatively little, since 87 percent of stomach cancer patients on Medicare are initially diagnosed during hospitalization and therefore would be recorded in CMHSF.

A fourth drawback is that Baker et al. (1989) provides no information concerning the duration of the maintenance period for stomach cancer. The analysis in this chapter assumed that stomach cancer survivors incur maintenance care costs for ten years. If the average duration of maintenance care among survivors of stomach cancer is shorter (longer) than ten years, the estimates of the costs incurred by survivors would be biased upward (downward). This is less of an issue for nonsurvivors' costs because the great majority of stomach cancer nonsurvivors die within the first few years. Because most stomach cancer patients (about 82 percent) are ultimately nonsurvivors, the duration of the maintenance period is of somewhat less importance for stomach cancer patients than for the 18 percent who ultimately survive the illness.

A fifth drawback is that the data used by Baker are from the period 1974 to 1981. Increased early detection and treatment modifications for stomach cancer have increased the life expectancy of those diagnosed with the disease.

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[7] This figure represents those enrolled in Medicare Part A; 95 percent of those enrolled in Medicare Part A choose also to enroll in Medicare Part B.

Finally, the reliability of the data contained in the database used by Baker et al. varies. An independent analysis of CMHSF performed in 1977 by the Institute of Medicine of the National Academy of Sciences found that the frequency of discrepancies in principal diagnoses varied among diseases (Baker et al., 1991). It is unclear whether the presence of misnamed diagnoses contained in CMHSF potentially increases or decreases the resultant cost estimates.

Overall, despite the limitations described above, Baker's analysis of the CMHSF data represents the most nationally-representative, per-patient lifetime estimate of the direct medical costs of treating stomach cancer to date. Their cost estimates are based on sound criteria. Some of the data limitations underestimate costs and others overestimate costs; the sum of the data limitations therefore decreases the magnitude of error. More of the uncertainties in their analysis appear to underestimate costs, however; the net result is a likely underestimation of actual direct medical costs.

Although some uncertainties are associated with the estimation of the survival and mortality probabilities used in the calculation of expected medical costs, these uncertainties are likely to be relatively small. As noted in the text, NCI RSRs used to estimate survival and mortality for this analysis are based on the survival experience of a large group of stomach cancer patients considered in relation to the survival experience of the general population. Although age-specific RSRs for each year post-diagnosis are not available, the age-specific five-year RSRs provided by NCI (1998) suggest that there is relatively little variation in RSRs across ages at diagnosis for stomach cancer patients.

An additional limitation of this analysis is that medical costs incurred as a result of stomach cancer, but not considered by Baker et al., may arise as a result of treatment for stomach cancer. Secondary cancers and other adverse health effects may occur due to radiation, chemotherapy treatment, and other therapies. These may occur substantially after stomach cancer treatment has been completed and can incur added medical costs not considered in this chapter.

Data have not yet been located regarding the average duration of maintenance care. For purposes of this analysis, ten years of follow-up care was assumed to be reasonable due to the severity of the disease and the consequences of stomach surgery. This assumption may be revised in the future if data are located.

II.2.D.2.   Scope of the Analysis

The analysis in this chapter was confined to direct medical costs by the patient. As noted in Chapter I.1, willingness-to-pay has many other cost elements. The analysis does not include time lost by the patient; their family and friends who provide care; pain and suffering on the part of the patient, family, and friends; changes in job status among previously employed patients, training for new job skills due to physical limitations; or medical costs incurred after the ten-year maintenance period. These cost elements may comprise a substantial portion of the total cost of stomach cancer.

Link to Chapter I.1

Appendix II.2-A Deriving the Probabilities of Dying of Stomach Cancer and Dying of Other Causes

This appendix contains a method to derive the probabilities of dying of stomach cancer and dying of other causes in the nth year in a cohort of stomach cancer patients who have survived to the nth year.

p	w
q1	q2
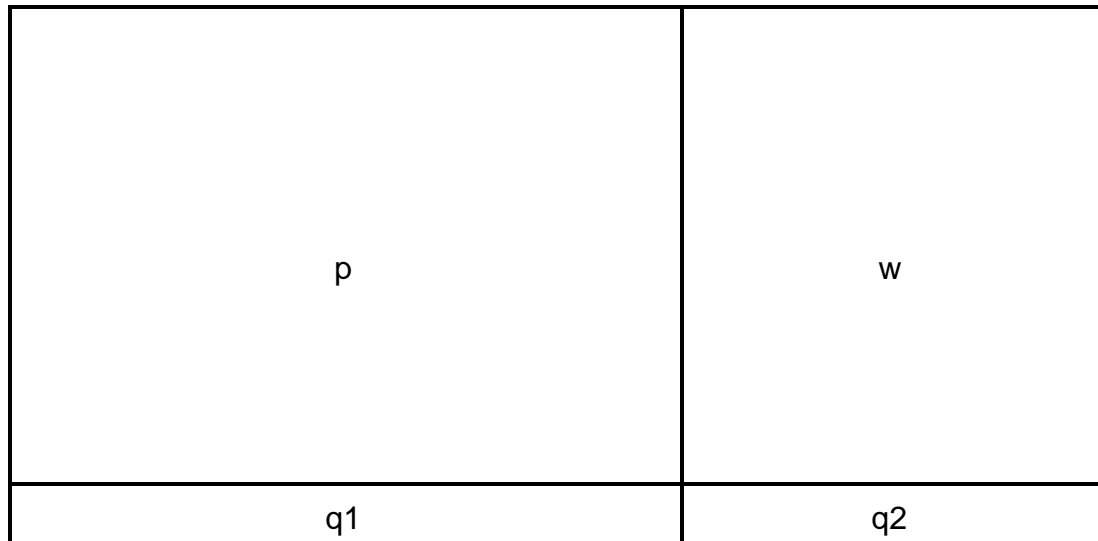
The diagram above represents the stomach cancer cohort remaining at the beginning of the nth year. The area of the entire box = the probability of having survived to the beginning of the nth year post-diagnosis = 1. That is, all probabilities described below are conditional on having survived to the beginning of the nth year post-diagnosis.

p = the proportion of the cohort who survive through the nth year (= the probability of surviving the nth year.)

q = the probability in the general population of dying of causes other than stomach cancer. We assume that the proportion of the stomach cancer cohort who *would* die of other causes if they were not a cohort of stomach cancer patients is also q.

q = q1 + q2 in the diagram.

z = the proportion of the cohort who *would* die of stomach cancer if there were no other causes of death.

z = w + q2 in the diagram.

q2   =   the portion of the cohort who *would* die of other causes if they were not stomach cancer patients but who *could* die instead of stomach cancer (because they are in fact stomach cancer patients).

    =   the portion of those who *would* die of stomach cancer if there were no other causes of death who *could* die instead of other causes (because there are in fact other causes of death).

    =   the intersection of z and q.

We assume that, of those who could die of either stomach cancer or other causes (q2), half will die of stomach cancer and half will die of other causes. Because this is a very small portion of the cohort, even if the split is not exactly 50-50, this should affect the results only minimally.

Let:

a   =   the proportion of the cohort who actually die of stomach cancer (= the probability of dying of stomach cancer in the stomach cancer cohort), and

b   =   the proportion of the cohort who actually die of other causes (= the probability of dying of other causes in the stomach cancer cohort).

Then:

a   = $w + 0.5 \times q2$, and
b   = $q1 + 0.5 \times q2 = (q - q2) + 0.5 \times q2 = q - 0.5 \times q2$

Because:

w   = $1 - p - q$ (see diagram), and
a   = $1 - p - q + 0.5 \times q2$

To solve for q2 in terms of known quantities (p and q), we use the following (see the diagram):

$$\frac{q2}{q} = \frac{w}{(w + p)} \quad .$$

(Recall that $q = q1 + q2$). This implies that

$$q2 = q \times \frac{w}{(w + p)} \quad .$$

We also know that w = 1 - p - q (see diagram). Substituting this into the above equation, we get q2 as a function of p and q, both of which are known:

$$q2 = (\frac{q}{1-q}) \times (1 - p - q) \ .$$

We can now derive a and b, given q2.

In summary,

$$q2 = (\frac{q}{1-q}) \times (1 - p - q) \ .$$

where, recall, a is the probability of a stomach cancer patient dying of stomach cancer during the nth year and b is the probability of a stomach cancer patient dying of other causes during the nth year.

$$a = 1 - p - q + 0.5 \times q2$$

$$b = q - 0.5 \times q2$$